

Report of the FESAC Proof of Principle Subpanel

May 2001



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Panel Members

Jeff Freidberg (Chair)

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Background Information and Summary of Charge



- | The PoP subpanel met in Knoxville in August 1999**
- | Our job was to determine whether or not the RFP, MTF, and CS were ready for PoP status**
- | We concluded that the RFP was ready for PoP status and should move ahead**
- | We concluded that MTF was not ready and recommended continuation as a CE level experiment**
- | We concluded that the main component of the CS program, the NCSX experiment, was not ready for PoP status**

Stellarators 101



Stellarators are toroidal helical devices

Advantages:

- | Inherently steady state**
- | Low or no problems with disruptions**
- | Reasonably high beta possible**

Disadvantages Opportunities:

- | Complicated and expensive**
- | Scale to large reactors**
- | Bad neoclassical losses**

The Quasi-Axisymmetric Stellarator (QAS)



- | NCSX is a QAS configuration**
- | QAS solves two of the problems**
- | QAS is compact**
- | QAS has low neoclassical losses**

How does QAS do this?

- | QAS is a stellarator that thinks it's a tokamak**
- | QAS is designed so that single particles see a mod-B field very similar to what they would see in a tokamak**
- | QAS has a substantial bootstrap current**
- | However, high bootstrap fraction is not necessary or desired for success**

What Was the Issue with NCSX?



- | The panel felt that the NCSX was an interesting idea with a lot of potential promise**
- | The issue was a technical one.**
- | We were not convinced that it was possible to evolve stably from a cold initial state to a high β final state.**
- | This was tricky because of the uncertain behavior of the self-consistent bootstrap current**
- | At the time of Knoxville, the NCSX team had not demonstrated such a stable evolution**

What Was Our Recommendation?



- | The NCSX team should carry out a more detailed design**
- | They should demonstrate that a stable evolution exists**
- | They should demonstrate that the evolutionary path is robust – not sensitive to small perturbations**
- | When the design was ready for a Physics Validation Review the PoP panel wanted to be present**
- | We would then re-evaluate whether NCSX was ready for PoP status**

The Physics Validation Review



- | The Physics Validation Review took place in March 2001**
- | The PoP subpanel was present**
- | Our charge was to determine whether or not NCSX was ready for PoP status**

What We Did and Did Not Do



- | We answered our charge in the narrow sense – was the NCSX design sufficiently robust to warrant PoP status?**
- | We did not raise any additional scientific questions.**
- | We wanted to avoid setting up a moving target for the NCSX team**
- | These issues were left for the Physics Validation Review**
- | We reviewed only the NCSX proposal**
- | We did not review the entire US stellarator PoP program**


What Were Our Conclusions and Recommendations?



- | The NCSX team has made substantial progress validating the robustness of QAS equilibria**
- | They have investigated a broad range of pressure and current profiles, beta values and start-up scenarios**
- | While there is more that can and should be done, the NCSX team convinced the panel of the robustness of the design**
- | We concluded that the NCSX design is ready for PoP status as the lead element in a stellarator PoP program**
- | The panel also noted that NCSX was a relatively costly investment for the fusion community lasting many years (\$55M for construction)**
- | We recommended that FESAC and OFES address the larger programmatic issues to see how, when and whether to proceed with construction**
- | Basically, we were asking for an update of the Knoxville Priorities and Balance Report**

Why Did We Raise This Issue?

- | The money counts**
- | There are other pressing needs in the program**
- | The Priorities and Balance Report sends mixed messages as to how we should proceed**
- | Some examples:**
 - 1. Aggressively pursue CE and PoP concepts**
 - 2. Prepare for a Burning Plasma experiment**
 - 3. Revitalize the technology program**
 - 4. Assess attractiveness of the CS in 10 years**
 - 5. Join international collaboration for a BPX**
 - 6. \$220M – seriously delay new PoP experiments**
 - 7. \$260M – initiate ICC expt's on a limited scale**
 - 8. \$260M – more fully utilize existing large expt's**
 - 9. \$300M – study promising ICC on a larger scale**

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- | Conclusion: If there is enough money we can do it all**
 - | My opinion: NCSX is a promising idea. It's future should not be determined by 3 year old mixed messages**
 - | The PoP subpanel wants FESAC to update and clarify the Knoxville recommendations**
 - | The PoP subpanel wants FESAC to lay out a detailed spending profile based on the current budget to show how NCSX can be built and operated**
 - | The PoP subpanel wants FESAC to make sure that other programmatic needs are kept in balance if NCSX is built**
 - | My opinion: Let's find a way to build this experiment**
 - | An open issue: FESAC needs examine and approve an overall stellarator PoP program consistent with budget constraints**